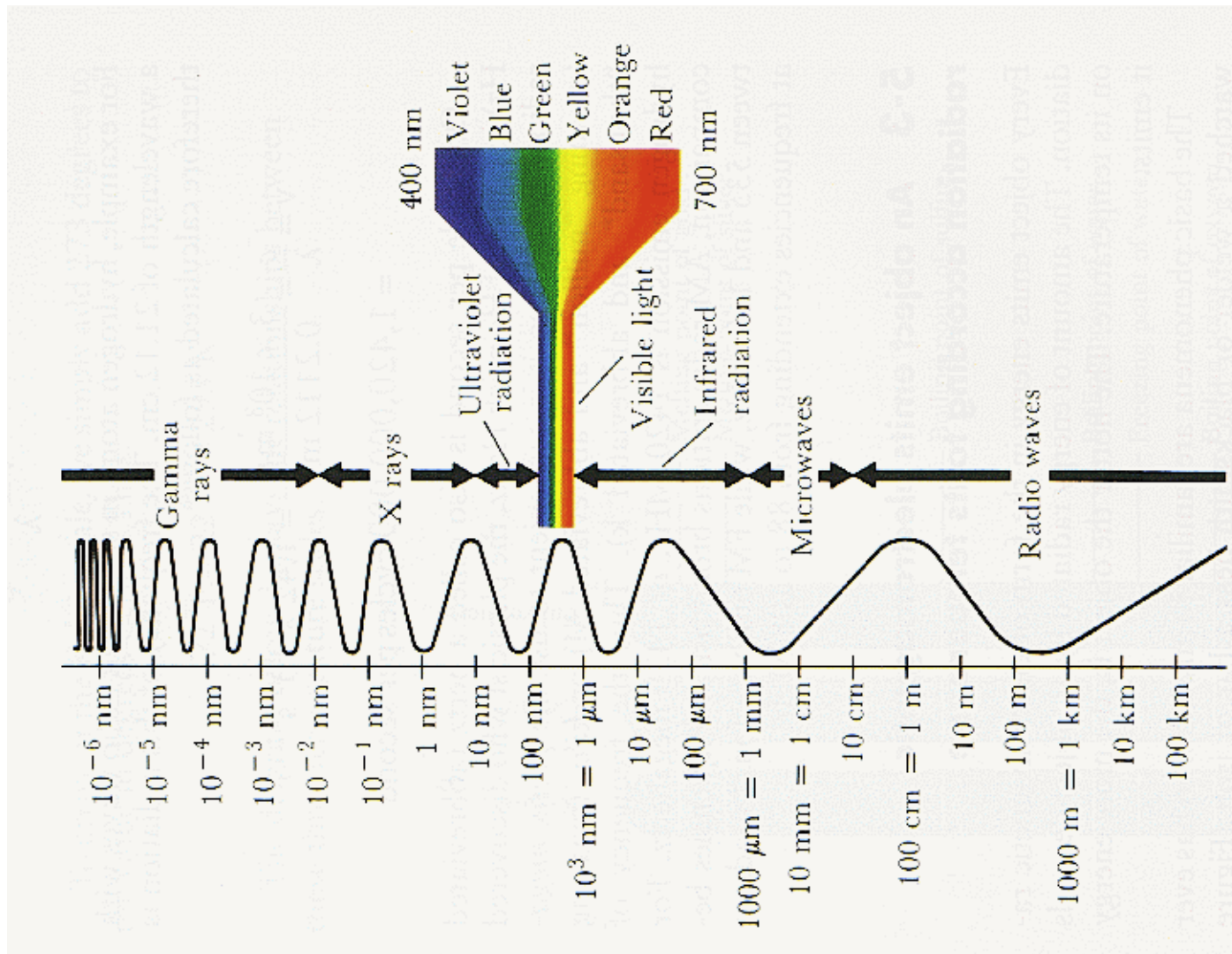


Public Safety Radio Communications Terms & Concepts



Credits

- The following presentation includes slides, or parts of slides, extracted from presentations formerly prepared by the:
 - Interoperable Communications Technical Assistance Program (ICTAP)
 - Department of Homeland Security
 - Contra Costa County Fire Protection District

Objective

- Refresh and augment attendee knowledge of contemporary two-way radio terms and concepts as it relates to public safety communications.

What are bands?
What are voting receivers?
What are repeaters?
What is “trunking”?

Terms and Concepts

- Frequency vs. Radio Channel
- Frequency Bands and Propagation
- Simplex vs. Duplex
- Repeater
- Voting Receiver
- Simulcast
- Narrow-banding
- Conventional vs. Trunked
- Analog vs. Digital (Project 25)

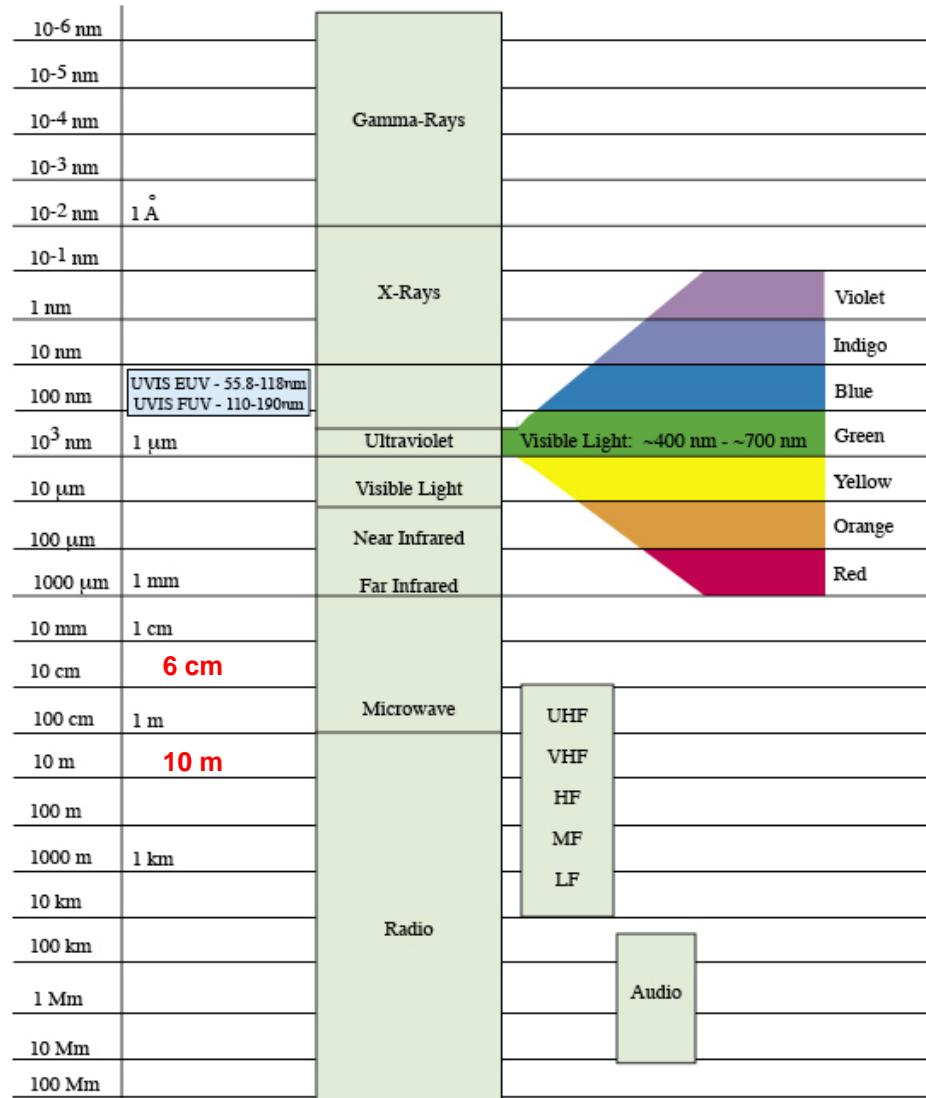
$$\lambda = \frac{c}{f}$$

$$(c \approx 3 \cdot 10^8 \text{ m/s} = 300,000 \text{ km/s})$$

Range of PS
Spectrum
(including
Broadband)

5 GHz
30 MHz

The Electromagnetic Spectrum



nm=nanometer, Å=angstrom, μm=micrometer, mm=millimeter,
cm=centimeter, m=meter, km=kilometer, Mm=Megameter

UNITED STATES FREQUENCY ALLOCATIONS THE RADIO SPECTRUM

RADIO SERVICES COLOR LEGEND

■ AERONAUTICAL MOBILE	■ INTERSATELLITE	■ RADIO ASTRONOMY
■ AERONAUTICAL MOBILE SATELLITE	■ LAND MOBILE	■ RADIO DETERMINATION
■ AERONAUTICAL RADIO NAVIGATION	■ LAND MOBILE SATELLITE	■ RADIO LOCATION
■ AMATEUR	■ MARITIME MOBILE	■ RADIO LOCATION SATELLITE
■ AMATEUR SATELLITE	■ MARITIME MOBILE SATELLITE	■ RADIO NAVIGATION
■ BROADCASTING	■ MARITIME RADIO NAVIGATION	■ RADIO NAVIGATION SATELLITE
■ BROADCASTING SATELLITE	■ METEOROLOGICAL AID	■ SPACE OPERATION
■ BATHYDEPTH SATELLITE	■ METEOROLOGICAL SATELLITE	■ SPACE RESEARCH
■ FIXED	■ MOBILE	■ STANDARD-FREQUENCY AND TIME SIGNAL
■ FIXED SATELLITE	■ MOBILE SATELLITE	■ STANDARD-FREQUENCY AND TIME SIGNAL SATELLITE

ACTIVITY CODE

■ GOVERNMENT EXCLUSIVE	■ GOVERNMENT/GOVERNMENT OWNED
■ NON-GOVERNMENT EXCLUSIVE	

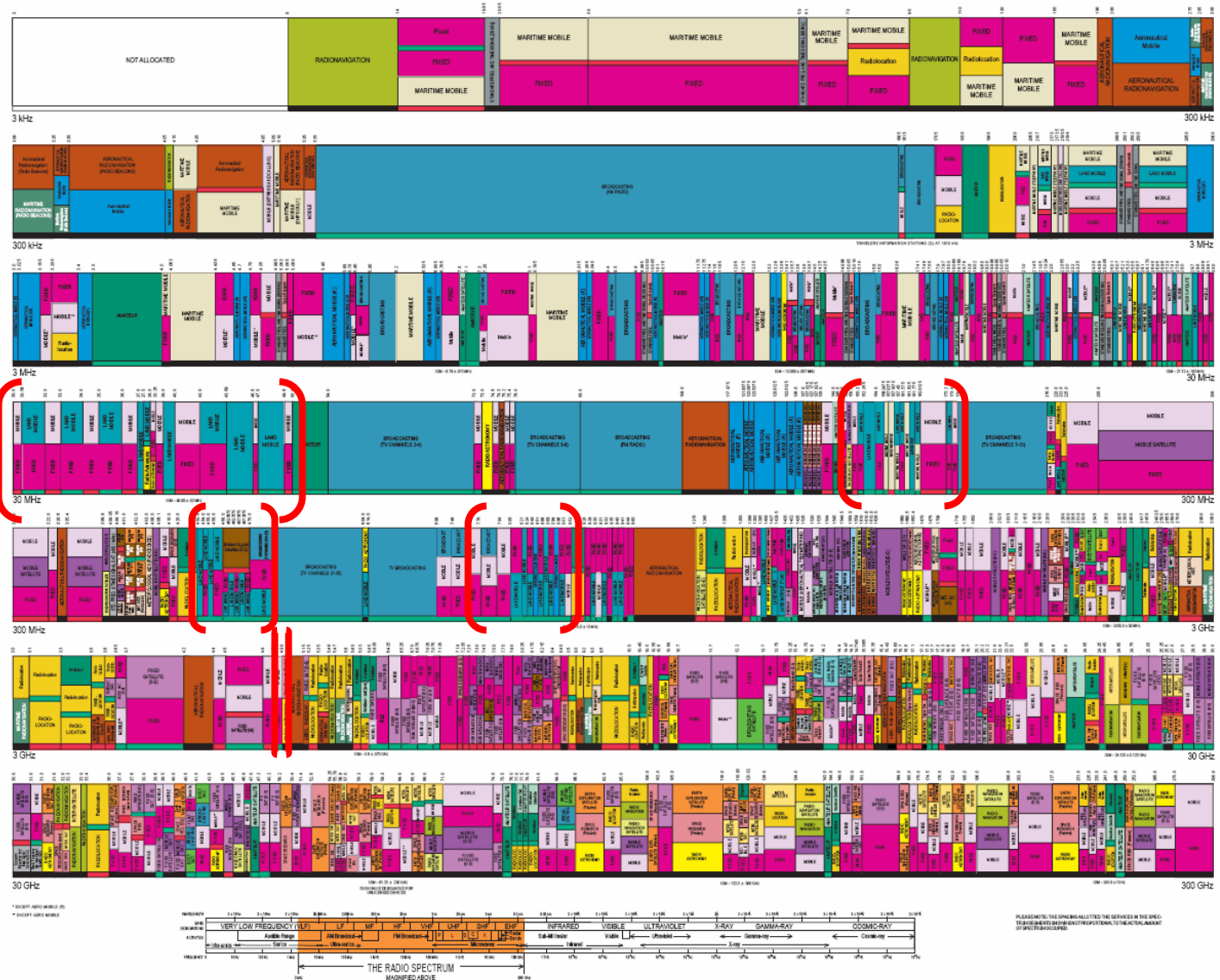
ALLOCATION USAGE DESIGNATION

SERVICE	EXAMPLE	DESCRIPTION
Primary	FIXED	Capital Letters
Secondary	Mobile	1st Capital with lower case letters

This chart is a graphic representation prepared by the U.S. Department of Commerce, National Telecommunications and Information Administration, Office of Spectrum Management. It does not constitute an official U.S. Government document and should not be used for legal purposes. It is intended for informational purposes only. The U.S. Department of Commerce, National Telecommunications and Information Administration, Office of Spectrum Management, is responsible for the content of this chart.



U.S. DEPARTMENT OF COMMERCE
National Telecommunications and Information Administration
Office of Spectrum Management
October 2023



Spectrum Managers

- ITU – International Telecommunications Union – Sets global policy
- FCC – Federal Communications Commission - Regulates the assignment and enforcement of all U.S. spectrum except covered by NTIA
- NTIA – National Telecommunications and Information Administration

Federal government solutions

1995 – PSWAC identified 25 MHz needed to meet near-term needs

1997 – Congress asked FCC to re-allocate 24 MHz (60 MHz. from TV Channels 60-69) to public safety

1998 - PSWN identified need for interoperability

1999 – NCC formed to implement new 700 MHz Band

2009 – 700 MHz Band available nationwide

Frequency vs. Radio Channel

A frequency is a specific, known location somewhere between DC voltage and daylight in the radio spectrum

For example:

0.810 MHz. is the frequency for an AM radio station

100.1 MHz. is a frequency within the FM radio band

154.920 MHz. is the frequency for a VHF radio channel

875.000 MHz. is a frequency within the cellular telephone range

6,000 MHz. is a frequency typically used by a Microwave system

10,525 MHz. is a frequency of a police radar gun

Public Safety Bands

- VHF Low band (30 to 50 MHz)
- VHF High band (136 to 174 MHz)
- UHF (450 to 470 MHz)
- UHF T-Band (470 to 512 MHz)
- 800 MHz (806 to 821 & 851 to 866 MHz)
- 800 MHz NPSPAC (821 to 824 & 866 to 869 MHz)
- 700 MHz (764-776 & 794-806 MHz)
- 4.9 GHz (4,940 to 4,990 GHz [Broadband])

Propagation & Band Characteristics

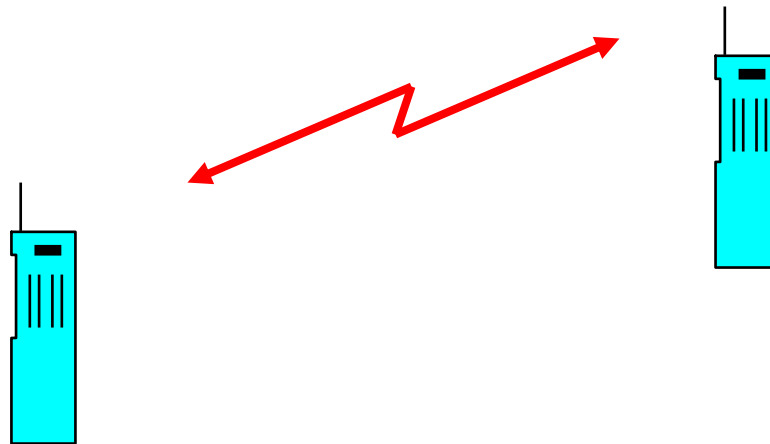
- VHF Low Band (30-50 MHz)
 - Best propagation in undeveloped and hilly terrain
 - Poor building penetration
- VHF High Band (150-174 MHz)
 - Very good propagation in undeveloped and hilly terrain
 - Moderate building penetration
- UHF (450-512 MHz)
 - Good propagation in undeveloped and hilly terrain
 - Good building penetration
- 700/800 MHz
 - Poor propagation in undeveloped and hilly terrain
 - Very good building penetration
 - 700 currently subject to incumbent television stations in some areas
 - 800 currently subject to interference from commercial carriers

Simplex

- Very Reliable
- Limited Range
- Single-Band

Radio Channel uses 1 frequency

Each user must be line of sight with each other

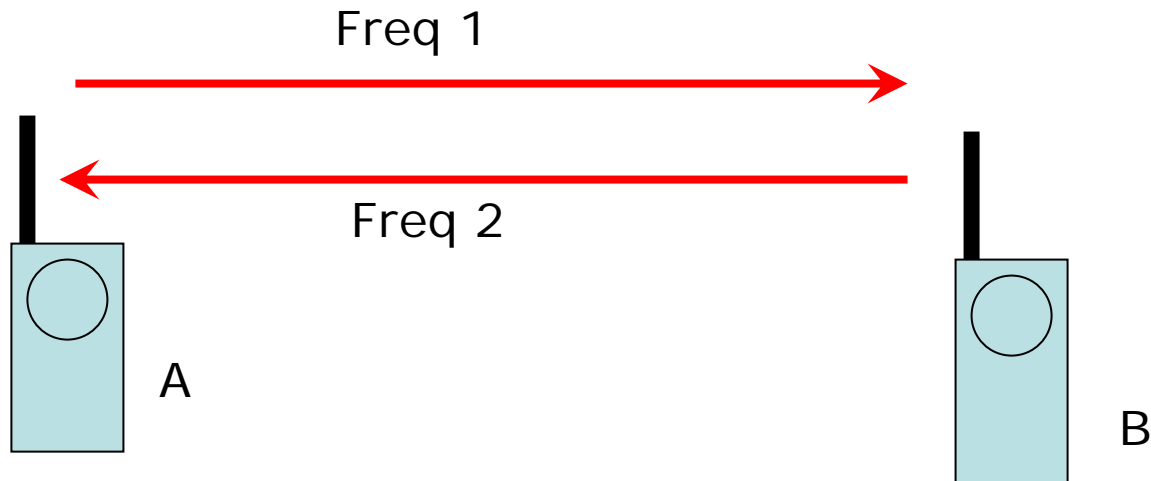


Duplex

Radio Channel using 2 frequencies, Freq 1 to talk from radio A to radio B, and Freq 2 to talk from radio B to radio A

Each user must be line of sight with each other

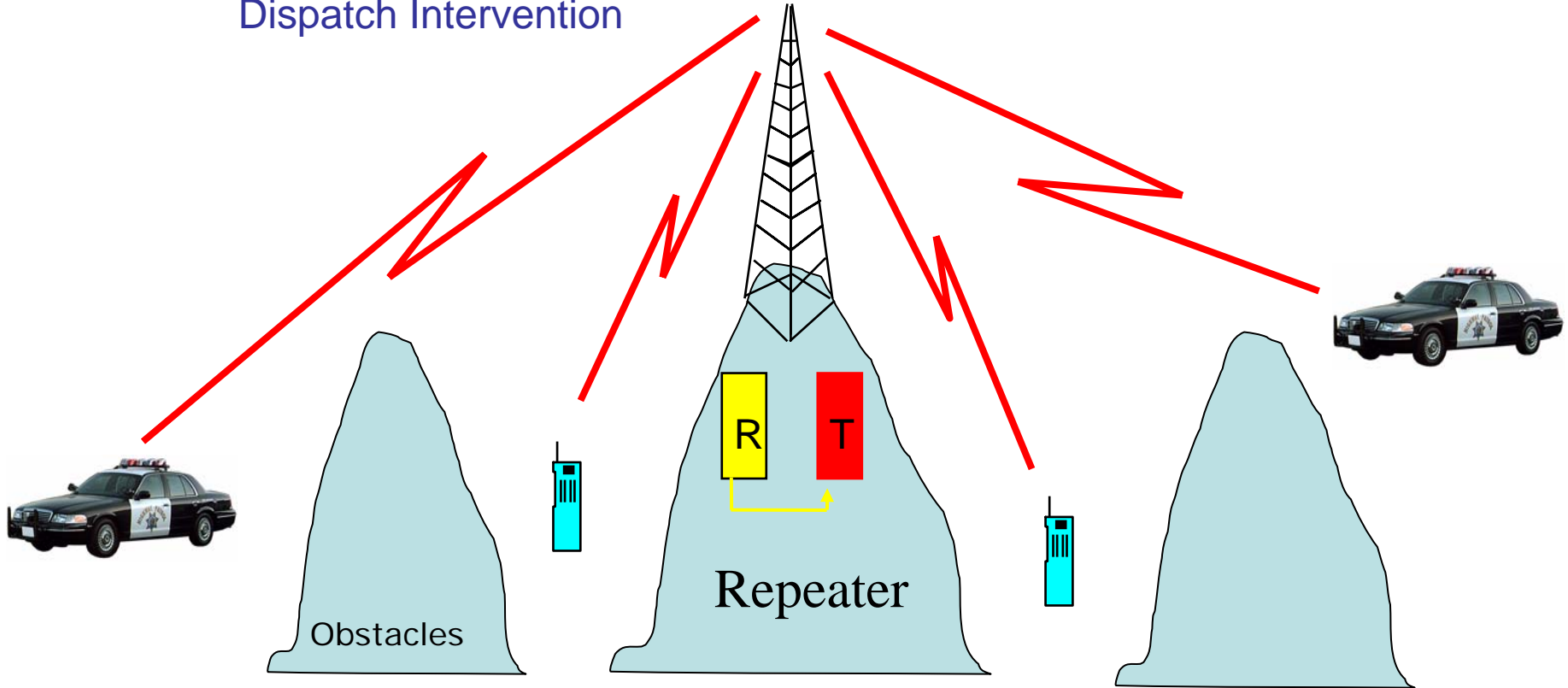
Examples: Cordless Telephone systems, which both parties can talk at the same time and listen at the same time.



Conventional Repeater

Each Repeater Uses 2 Frequencies, 1 for Receive and 1 for Transmit

- Increased Coverage Area vs. Simplex (or Direct)
- Radio User Must Be Within Range of Base Receiver
- Portable Repeaters Extend Direct Range
- Cross-Band Operation Possible with Dedicated Channel and/or Dispatch Intervention



Conventional Systems

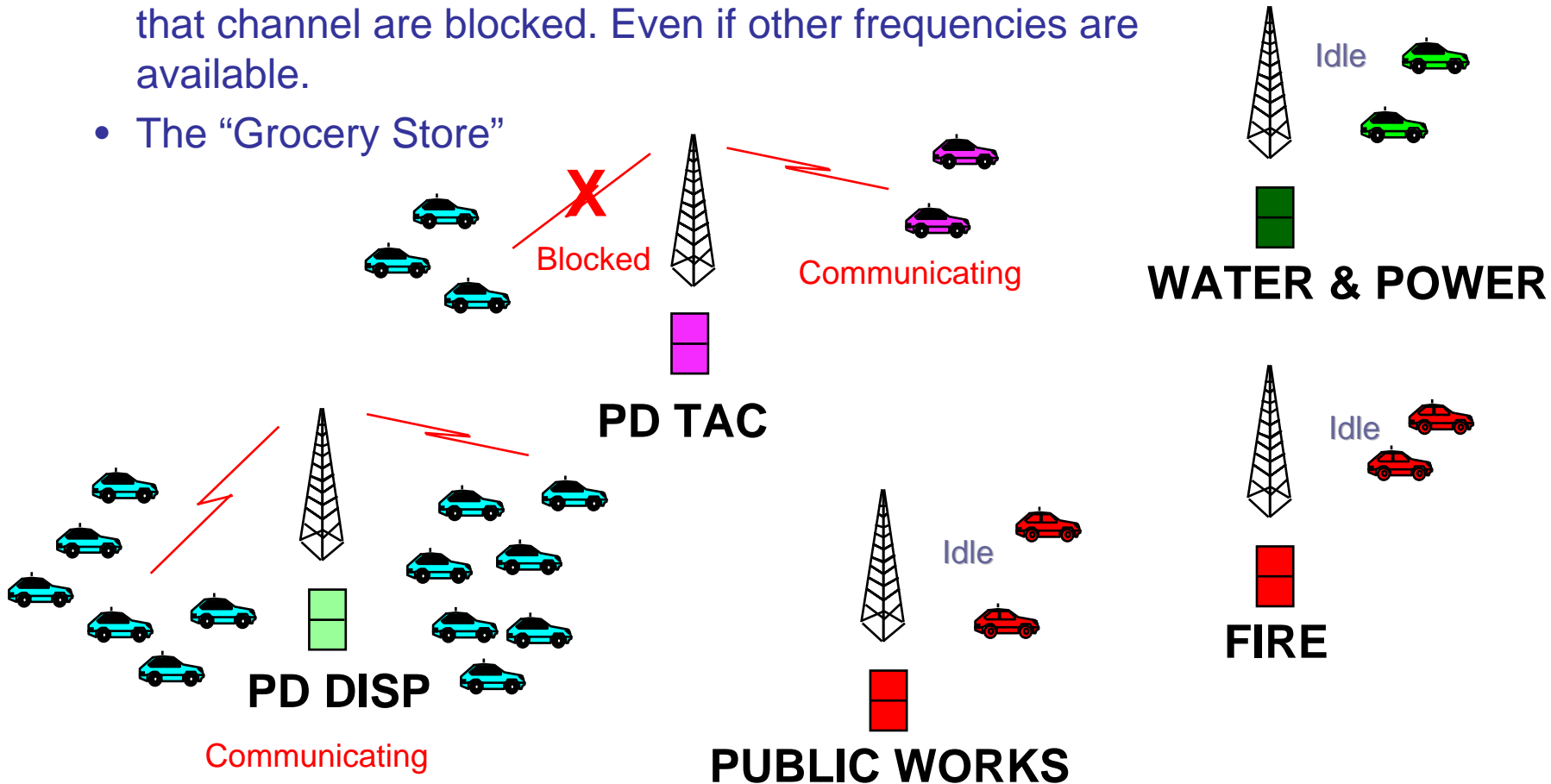
- One transmission per channel at a time.
- Maximum number of simultaneous transmissions is defined by the number of channels within a specific area

Conventional Repeater

Stovepipe or Vertical Systems

– Inefficient Use of Spectrum

- When one user group is talking, other user groups on that channel are blocked. Even if other frequencies are available.
- The “Grocery Store”

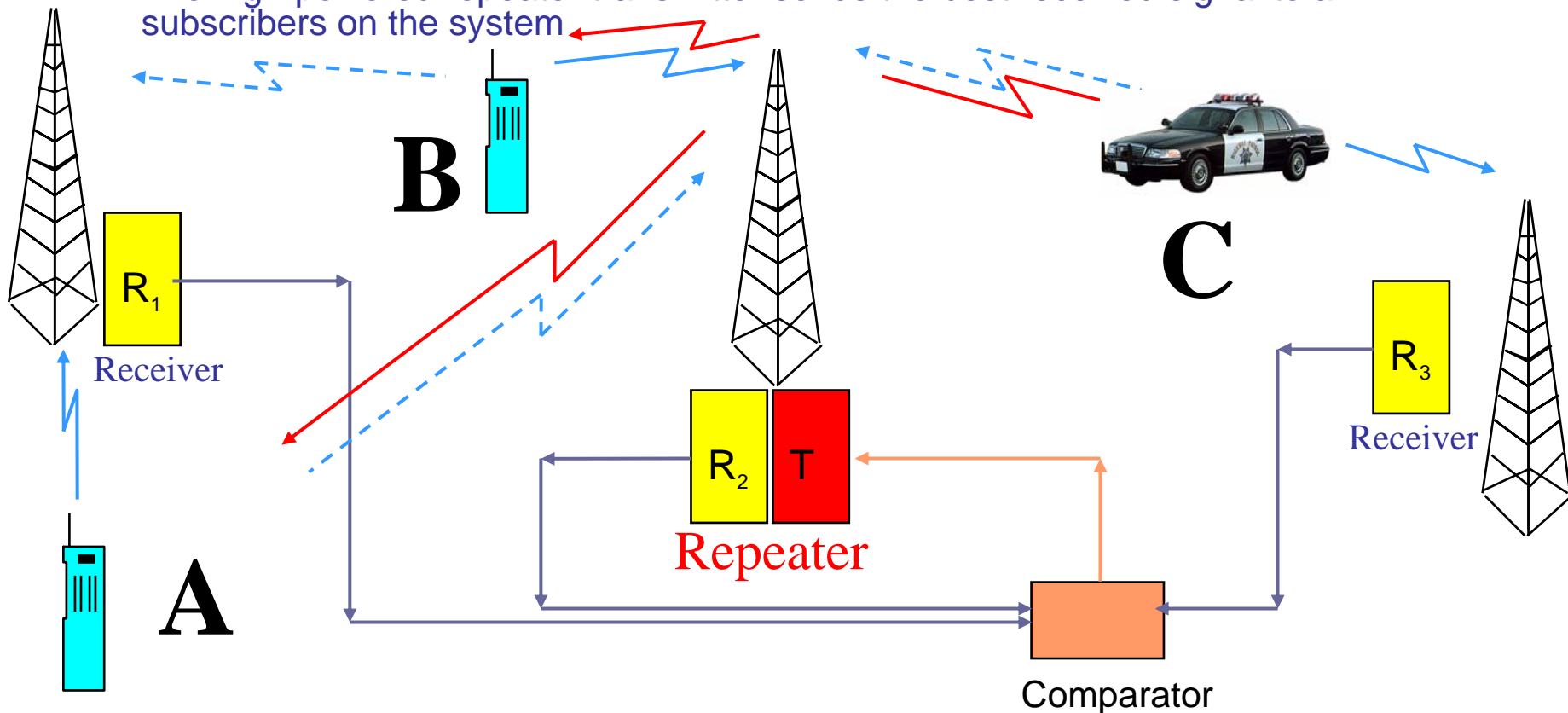


Voting Receivers

Extending Field Radio Range

Each low power subscriber radio talks to all receivers in its vicinity

- The received signal from all receivers “hearing” the subscriber send those signals to the comparator
- The comparator “compares” the signals and forwards the best received signal to the repeater
- The high-powered repeater transmitter sends the best received signal to all subscribers on the system



Modulation Choices Include

- Analog
 - Natural sounding voice
 - Signal loss is linear
- Standards Based Digital Project 25
 - Open architecture
 - Slightly artificial sounding – Due to digital voice
 - Range comparable to/better than analog
 - Sudden loss of recoverable audio
 - End-to-end and cross-band encryption possible with Over-The-Air-Rekeying of Crypto Keys
 - Numerous manufacturers

Project 25

NTIA has mandated the use of Project 25 for federal agencies.

FCC has mandated Project 25 for the interoperability channels in the new 700 MHz band.

U.S. DHS has indicated the acquisition of Project 25 systems is preferred (not currently mandatory) when purchasing radio systems with grant funding.

Project 25

Phase 1- 12.5 kHz. or 2 voice paths within 25 kHz. (19,200 baud possible in 25 kHz)

Phase 2 – 6.25 kHz or 2 voice paths within 12.5 kHz. (9,600 baud possible in 12.5 kHz)

Trunked Systems

Trunking

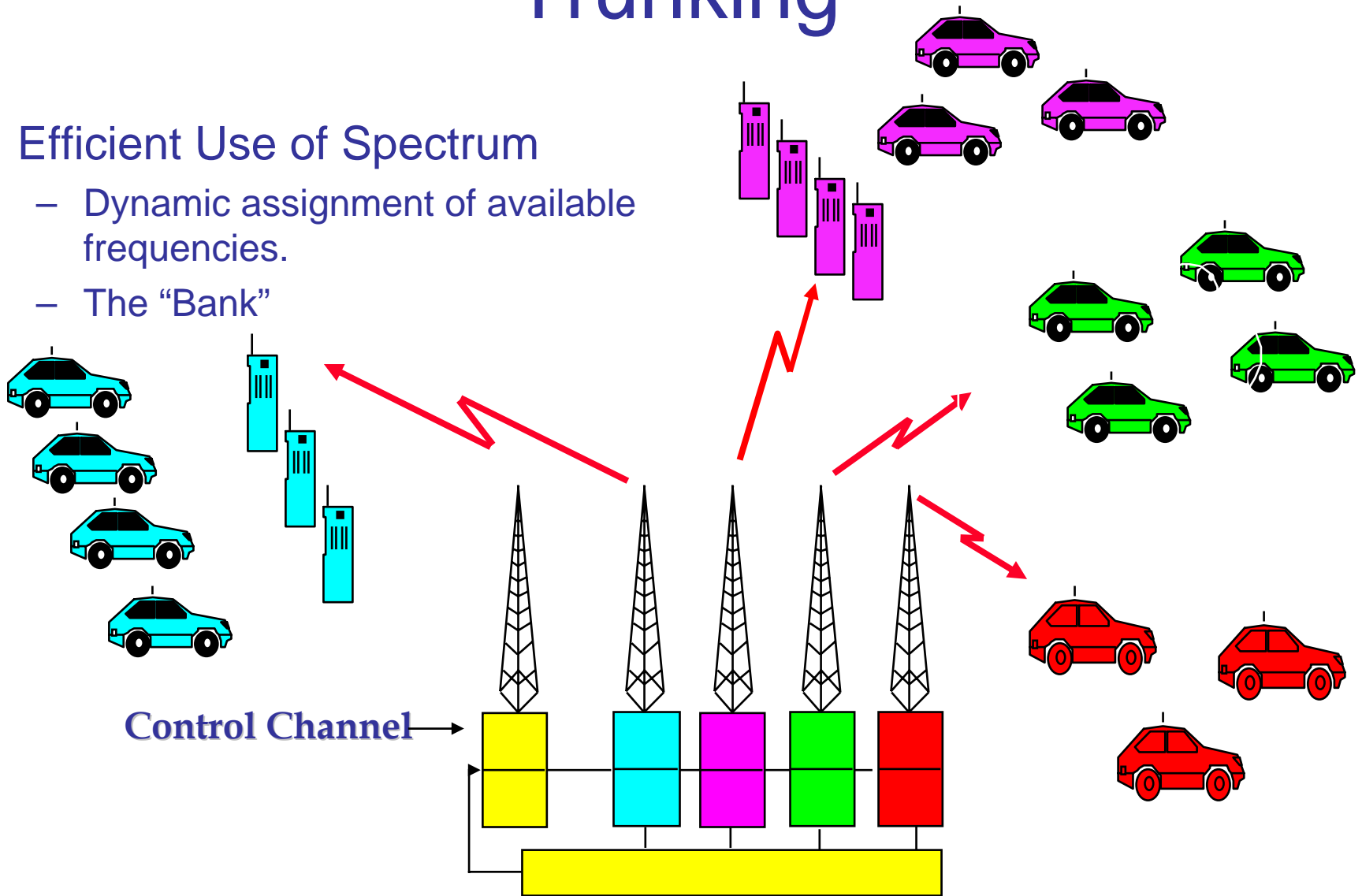
- If the number of subscriber units is high enough, a trunked system can increase efficiency.
- A system controller directs requests for a channel to unused channels or queues them on a next available or priority basis.

Trunking

- Minimum of 5 radio frequencies
- Some systems use one channel as a control channel that would leave 4 available for voice or data use
- Some systems switch frequencies between each transmission, some switch between each conversation

Trunking

- Efficient Use of Spectrum
 - Dynamic assignment of available frequencies.
 - The “Bank”



Trunking

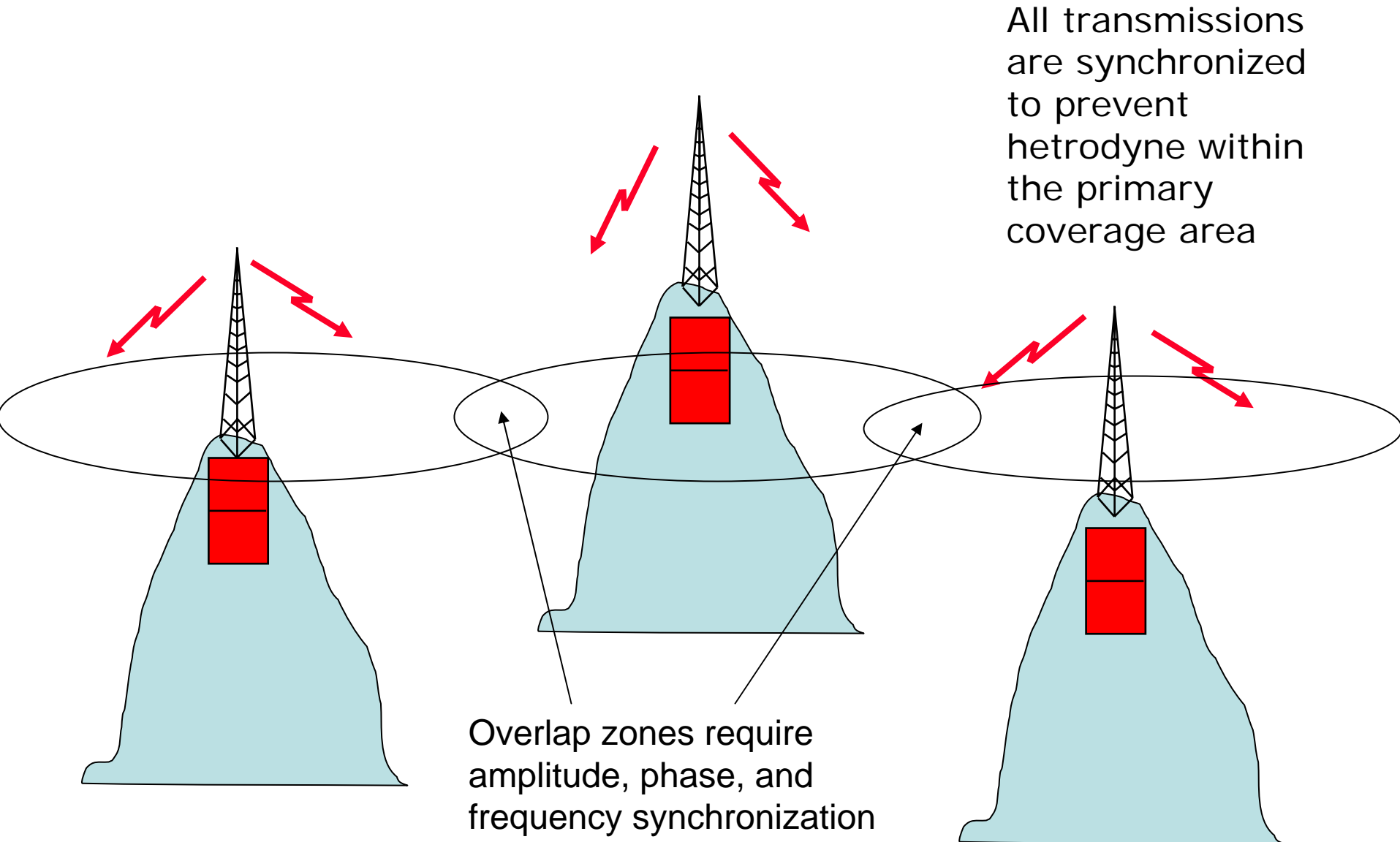
- Greatly Increased System Capacity
 - Controller Assigns Frequencies Dynamically
 - Permits the use of otherwise idle airtime on any channel.
 - “Virtual channels” called Talkgroups are defined for each system and user group
 - » There can be more talkgroups than actual RF channels
 - » Can be assigned to internal users or to other jurisdictions
 - One channel is dedicated as a digital control channel that steers all user radios to the proper RF channel for their talkgroup.
- As with conventional repeaters, radio users must be within range of a receiver.

Simulcast

Using “simulcast” technology, multiple coordinated sites transmit simultaneously.

Each transmitter reinforces the others, filling in areas where the others can not reach.

Simulcast



Narrow Banding + Implications

- There's an FCC mandate lurking outside your communications center, and it's been around for many years. It says you have until January 1, 2013 to migrate from your wide band (25 kHz) radio systems to narrowband (12.5 kHz or less). This applies to licensees using the LMR spectrum below 512 MHz. If you operate channels in the 150 -174 MHz (VHF high-band), 450–470 and 470–512 MHz (UHF bands), this means you. *David Pociluyko, Senior Communications Engineer CTA Communications, Inc.*

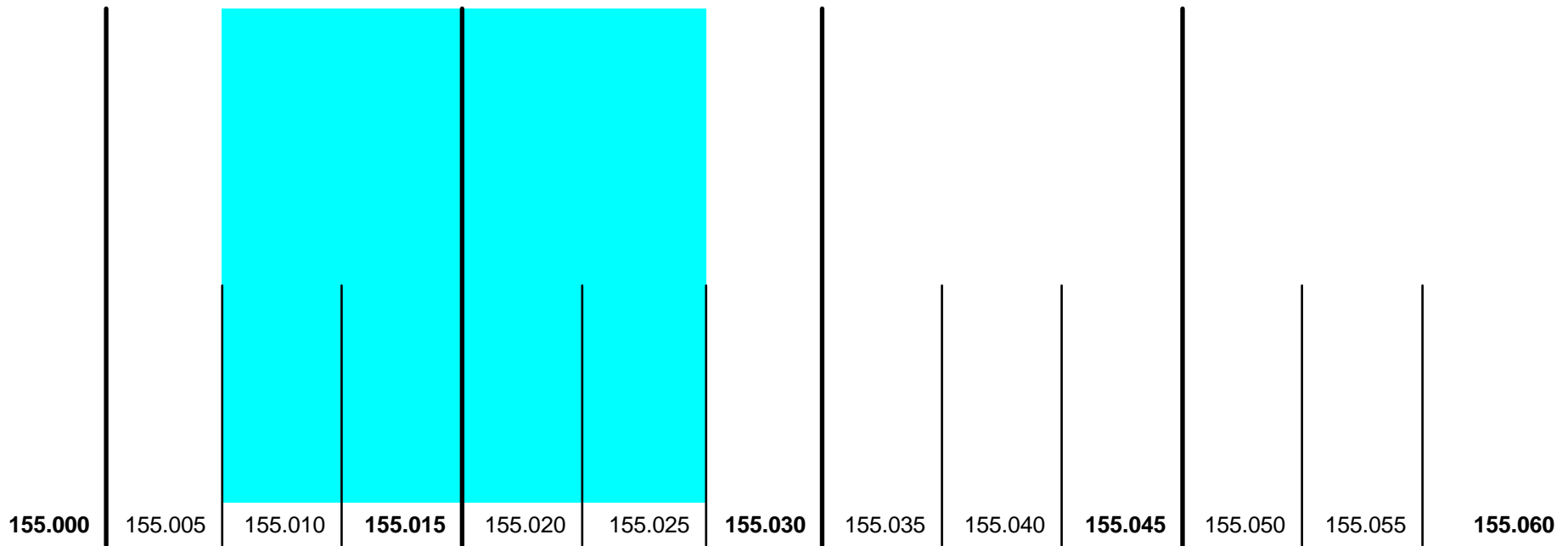
Spectrum Changes

**IRAC - Federal Government Mandate -
Narrowband by 2005**

**FCC – State & Local Govt. Mandate –
Narrowband by 2013**

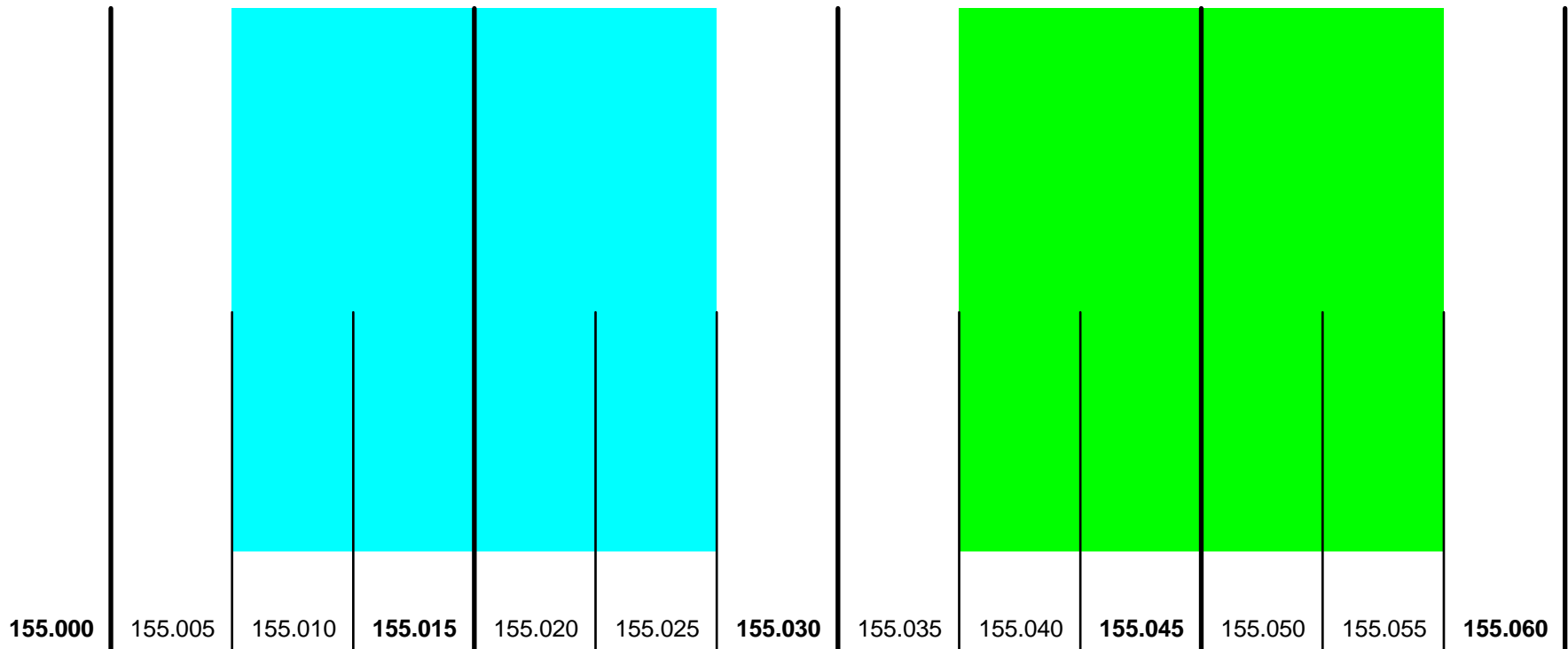
Narrow-Banding

Single frequency (heavy lines are 15 KHz.)
20 KHz. Modulation
155.015 center frequency



Narrow-Banding

30 kHz Channel Spacing (heavy lines are 15 kHz
20 kHz Modulation
155.015 MHz. center frequency and 155.045 center
frequency

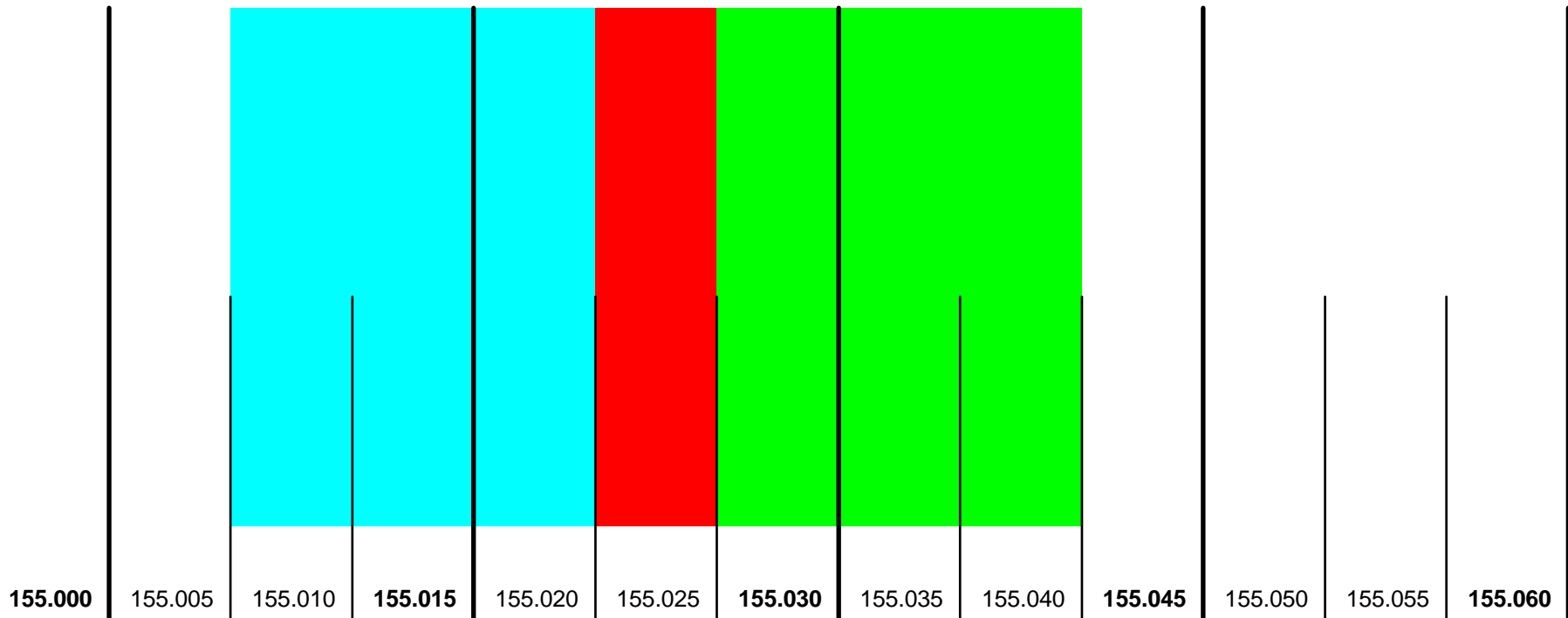


Narrow-Banding

15 kHz Channel Spacing (heavy lines are 15 kHz)

20 kHz Modulation

155.015 MHz center frequency and
155.030 MHz center frequency

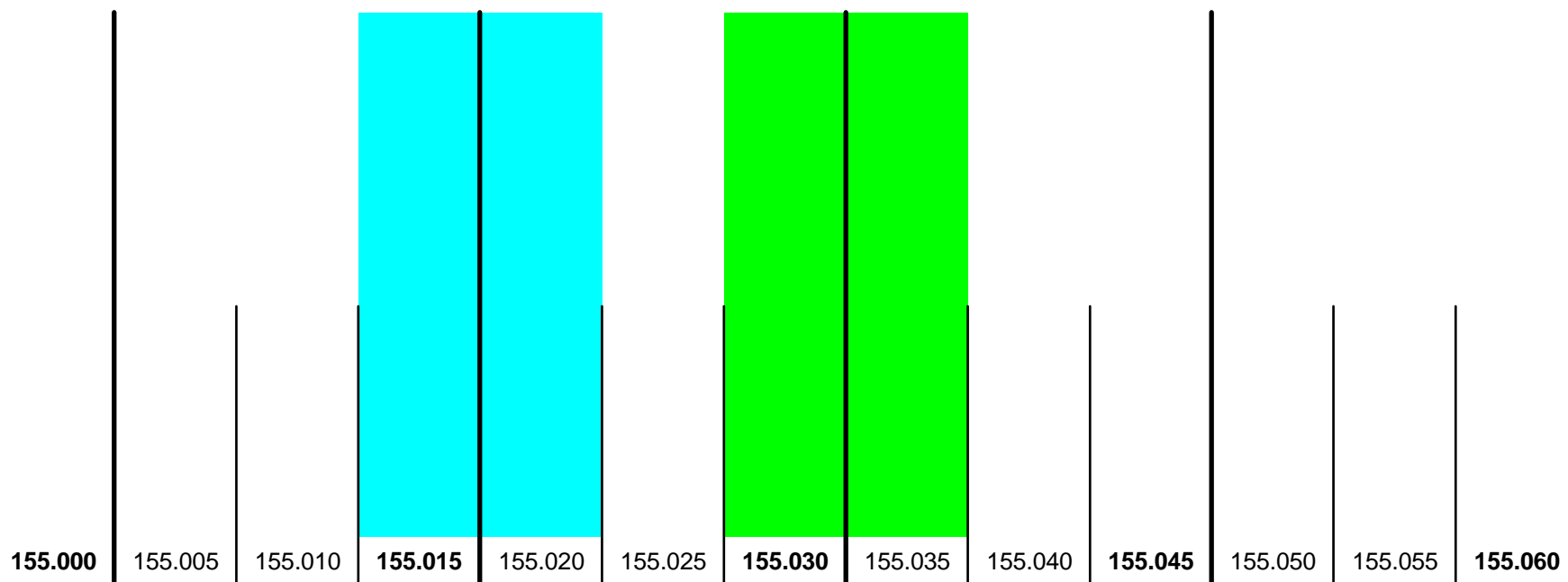


Narrow-Banding

15 KHz. Channel Spacing (heavy lines are 15 KHz.)

11 KHz. Modulation *NARROWBAND*

155.015 MHz. center frequency and 155.030
center frequency



What is Interoperability?

INTEROPERABILITY

Wireless communications interoperability specifically refers to the ability of public safety officials to share information via voice and data signals on demand,
in real time, when needed, and as authorized.

INTEROPERABILITY

- The ability to talk to who you need to talk to when you need to talk to them (data and voice, real-time).
- **NOT** the ability to talk with everyone all of the time!
- It is a complex issue involving Governance, SOPs, Technology, Training/Exercises and Regular Use

Questions



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Telecommunications Division*